

MULTI-STAGE TUBE FORGING METHOD FOR DISPROPORTIONALLY
ENLARGING AN END SECTION OF AN ALUMINUM ALLOY TUBE OF A BICYCLE
FRAME PART

5 CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part (CIP)
of co-pending U.S. Patent Application Serial No.
10/211,550, filed by the applicant on August 5, 2002,
the entire disclosure of which is incorporated herein
10 by reference.

BACKGROUND OF THE INVENTION

1. Field of the invention

This invention relates to a multi-stage tube
forging method for disproportionally enlarging an end
15 section of an aluminum alloy tube of a bicycle frame
part.

2. Description of the related art

Fig. 1 illustrates a conventional method of
forming a bicycle tube that includes the steps of
20 cutting a hollow rigid tube 1 having a predetermined
length, and placing the tube 1 thus cut in a tube forming
machine. During the tube forming operation, the middle
section of the tube 1 is clamped by a positioning clamp
seat 11 of the tube forming machine, with a pair of
25 mandrels 13 inserted respectively and movably into
two opposite ends of the tube 1 and a pair of mold
components 12 sleeved respectively and movably on the

ends of the tube 1. The inner diameter and wall thickness of the tube 1 are changed along the length of the tube 1 as a result of the movement of the mold components 12 and the pair of mandrels 13.

5 U.S. Patent No. 6,453,714 describes a method for forming an eccentrically expanded pipe that includes the steps of coaxially expanding a portion of a base pipe 2 at least one time by using a first expander punch (not shown) to form an expanded portion 21, an
10 intermediate tapering portion 22 and a neck portion 23, and as shown in Fig. 2, decentering the expanded portion 21 and the neck portion 23 relative to one another by using a second expander punch 24 having a diameter larger than that of the first expander punch.

15 The abovementioned conventional methods are disadvantageous in that the body of either the tube 1 or the base pipe 2 is subjected to a relatively large internal stress therein. In addition, if the tube 1 or the base pipe 2 is made from aluminum alloy, the
20 same tends to break during the enlarging operation.

SUMMARY OF THE INVENTION

Therefore, the object of the present invention is to provide a multi-stage tube forging method for disproportionally enlarging an end section of an
25 aluminum alloy tube that is capable of overcoming the aforesaid problems associated with the prior art.

According to the present invention, the multi-

stage tube forging method for disproportionally enlarging an end section of an aluminum alloy tube comprises the steps of: (a) drawing the aluminum alloy tube to form a thin section and a thick end section
5 extending from the thin section, wherein the thin section has a wall thickness thinner than that of the thick end section; (b) radially and proportionally enlarging the cross-section of the thick end section of the aluminum alloy tube by forging the aluminum
10 alloy tube in a first die using a first mandrel in such a manner that the wall thickness of the thick end section after being enlarged is substantially the same as that of the thin section; and (c) disproportionally varying the cross-section of the
15 thick end section of the aluminum alloy tube by forging the aluminum alloy tube obtained in step (b) in a second die using a second mandrel.

Preferably, the perimeter of an end edge of the thick end section of the aluminum alloy tube obtained
20 after step (c) is substantially equal to that of the end edge of the thick end section of the aluminum alloy tube obtained after step (b) and before step (c).

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings which illustrate an embodiment
25 of the invention,

Fig. 1 illustrates a conventional method of forming a bicycle tube;

Fig. 2 illustrates an eccentrically expanding operation of a conventional method for forming an eccentrically expanded pipe;

Fig. 3 is a block diagram illustrating
5 consecutive steps of the preferred embodiment of a multi-stage forging method of this invention for disproportionally enlarging an end section of an aluminum alloy tube of a bicycle frame part;

Fig. 4 is a schematic cross-sectional view to
10 illustrate how the aluminum alloy tube is drawn to form a thin section and a thick end section in the preferred embodiment of the present invention;

Fig. 5 is a schematic cross-sectional view to
15 illustrate how the aluminum alloy tube is inserted into a first die in the preferred embodiment of the present invention;

Fig. 6 is a schematic cross-sectional view to
illustrate how the aluminum alloy tube is forged through a first mandrel in the preferred embodiment
20 of the present invention;

Fig. 7 is a schematic cross-sectional view to
illustrate how the aluminum alloy tube of Fig. 6 is inserted into a second die;

Fig. 8 is a schematic cross-sectional view to
25 illustrate how the aluminum alloy tube of Fig. 7 is subjected to a second forging operation through a second mandrel;

Fig. 9 is a cross-sectional view of the thick end section of the aluminum alloy tube resulting from the forging operation shown in Fig. 8; and

Figs. 10 and 11 are perspective views to illustrate various shapes of the thick end section of the aluminum alloy tube that can be formed according to the method of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figs. 3 to 9 illustrate consecutive steps of a preferred embodiment of a multi-stage forging method of this invention for disproportionally enlarging an end section of an aluminum alloy tube 3 of a bicycle frame part (see Fig. 9). The method includes the steps of: (a) preparing the aluminum alloy tube 3 having a predetermined length, first and second dies 4, 6 with end sections that respectively define first and second shape-forming cavities 41, 61, and first and second mandrels 5, 7 with shape-forming ends 51, 71 that have cross-sections respectively corresponding to those of the end sections of the first and second dies 4, 6 (see Figs. 6 and 8); (b) drawing the aluminum alloy tube 3 to form a thin section 31 and a thick end section 32 extending from the thin section 31, wherein the thin section 31 has a wall thickness thinner than that of the thick end section 32 (see Fig. 4); (c) inserting the thin section 31 of the aluminum alloy tube 3 into the first shape-forming cavity 41 in the

first die 4, as illustrated in Fig. 5; (d) radially and proportionally enlarging the cross-section of the thick end section 32 of the aluminum alloy tube 3 relative to a centerline (X) of the aluminum alloy tube 3 by forging the aluminum alloy tube 3 in the first shape-forming cavity 41 with the shape-forming end 51 of the first mandrel 50 inserted into the thick end section 32 of the aluminum alloy tube 3 in such a manner that the wall thickness of the thick end section 32 after being enlarged is substantially the same as that of the thin section 31, as best illustrated in Fig. 6; and (e) disproportionally varying the cross-section of the thick end section 32 of the aluminum alloy tube 3 by forging the aluminum alloy tube 3 obtained in step (d) in the second shape-forming cavity 61 with the shape-forming end 71 of the second mandrel 70 inserted into the thick end section 32 of the aluminum alloy tube 3, as illustrated in Figs. 7 to 9. The thick end section 32 of the aluminum alloy tube 3 is forged in step (e) in such a manner that a portion 321 of the cross-section of the thick end section 32 of the aluminum alloy tube 3 is reduced and the remaining portion 322 of the cross-section of the thick end section 32 of the aluminum alloy tube 3 is further enlarged (see Fig. 7), and that the perimeter of an end edge 324 of the end section 32 of the aluminum alloy tube 3 obtained after step (e)

(see Fig. 9) is substantially equal to that of the end edge 324 of the thick end section 32 of the aluminum alloy tube 3 obtained after step (d) and before step (e).

5 Figs. 10 and 11 respectively illustrate various shapes of the thick end section 32 of the aluminum alloy tube 3 of a bicycle frame part that can be formed according to the method of this invention.

Preferably, in this embodiment, the aluminum
10 alloy tube 3 is cleaned and subsequently immersed in a lubricant medium before the drawing operation of step (b).

In addition, if the aluminum alloy tube 3 is hardened before the drawing operation, the aluminum
15 alloy tube 3 may be partially annealed prior to the drawing operation of step (b). More preferably, the partial annealing operation is conducted at a temperature ranging from 350°C to 380°C for 2 to 3 hours. Most preferably, the partial annealing operation is
20 conducted at a temperature of 355°C for 2.5 hours.

Preferably, in this embodiment, the aluminum alloy tube 3 is completely annealed prior to the insertion of the aluminum alloy tube 3 into the first die 4 in step (c). More preferably, the complete
25 annealing operation is conducted at a temperature ranging from 400°C to 420°C for 2 to 3 hours. Most preferably, the complete annealing operation is

conducted at a temperature of 410°C for 2.5 hours. Additionally, before the complete annealing operation, the aluminum alloy tube 3 is cleaned by using a detergent to remove the lubricant coated on the
5 aluminum alloy tube 3.

By virtue of the drawing operation and the complete annealing operation before conduction of the enlarging operation, the aforesaid drawbacks as encountered in the prior art can be eliminated. In
10 addition, the thick end section 32 of the aluminum alloy tube 3, which is disproportionally enlarged according to the method of this invention, possesses a surface texture with regularly and gradually developed wrinkles that enhance the appearance of the
15 aluminum alloy tube 3.

With the invention thus explained, it is apparent that various modifications and variations can be made without departing from the spirit of the present invention. It is therefore intended that the invention
20 be limited only as recited in the appended claims.